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Systematic Review

Evidence for effectiveness of Extracorporal Shock-Wave Therapy (ESWT) to treat calcific and non-calcific rotator cuff tendinosis – A systematic review

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ABSTRACT

Extracorporeal shock-wave therapy (ESWT) is suggested as a treatment alternative for calcific and non-calcific rotator cuff tendinosis (RC-tendinosis), which may decrease the need for surgery. In this study we assessed the evidence for effectiveness of ESWT for these disorders. The Cochrane Library, PubMed, Embase, Pedro, and Cinahl were searched for relevant systematic reviews and RCTs. Two reviewers independently extracted data and assessed the methodological quality.

Seventeen RCTs (11 calcific, 6 non-calcific) were included. For calcific RC-tendinosis, strong evidence was found for effectiveness in favour of high-ESWT versus low-ESWT in short-term. Moderate evidence was found in favour of high-ESWT versus placebo in short-, mid- and long-term and versus low-ESWT in mid- and long-term. Moreover, high-ESWT was more effective (moderate evidence) with focus on calcific deposit versus focus on tuberculum major in short- and long-term. RSWT was more effective (moderate evidence) than placebo in mid-term.

For non-calcific RC-tendinosis, no strong or moderate evidence was found in favour of low-, mid- or high-ESWT versus placebo, each other, or other treatments.

This review shows that only high-ESWT is effective for treating calcific RC-tendinosis. No evidence was found for the effectiveness of ESWT to treat non-calcific RC-tendinosis.

1. Introduction

Shoulder impingement syndrome (SIS) is the most frequently reported specific diagnosis in patients with CANS (Complaints of the Arm, Neck and/or Shoulder) (Huisstede et al., 2007; Feleus et al., 2008). Of those visiting their GP with a new episode of CANS, 33% are diagnosed with SIS (Feleus et al., 2008). Work-related factors associated with the occurrence of SIS are highly repetitive work, forceful exertion in work, awkward postures, and high psychosocial job demand (van Rijn et al., 2010). The consequences of SIS are functional loss and disability. Pathology of SIS is considered to be the principal cause of pain and symptoms arising from the shoulder. In general, the diagnosis SIS relates more to a clinical hypothesis as to the underlying cause of the symptoms than to definitive evidence of the histological basis for the diagnosis or the correlation between structural failure and symptoms (Lewis, 2009).

Some patients with SIS have calcific tendinosis, a reactive calcification that affects one of the rotator cuff tendons, which leads to the characteristic impingement symptoms (Sabeti-Aschraf et al., 2005). In the last 20 years extracorporeal shock-wave therapy (ESWT) has been used to treat soft tissue pain in the vicinity of bone structures (Chow and Cheing, 2007). The non-invasive ESWT is achieved through acoustic waves associated with a sudden rise in pressure generated by electrohydraulic, piezoelectric and electromagnetic devices resulting in release of low-, medium- or high-energy extracorporeal shockwaves (Uhthoff and Sarkar, 1989; Ogden et al., 2001). ESWT is currently applied to treat chronic enthesiopathies such as epicondylitis, plantar heel spur, and calcifying rotator cuff tendinosis (RC-tendinosis) (Gerdesmeyer et al., 2002). The exact mechanism by which ESWT relieves tendon-associated pain is still unclear. The theoretical benefits are the stimulation of tissue healing (Schmitz and DePace, 2009). and the breakdown of calcification (Loew et al., 1995). Of those with a calcific RC-tendinosis, the supraspinatus tendon is most affected (80%) followed by the infraspinatus tendon (15%) and subscapularis tendon (5%) (Bosworth, 1941; Molé et al., 1997; Bianchi and Martinoli, 2007). For these patients, ESWT is supposed to be successful. Moreover, ESWT is suggested to play a role in the management of non-calcific

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RC-tendinosis, especially in those who have had repeated non-surgical treatment failures (Chung and Wiley, 2002).

The purpose of this study is to present an evidence-based overview of the effectiveness of ESWT for the management of calcific and non-calcific RC-tendinosis. This information can be helpful to further optimize the quality of care for patients with these disorders. Further, it can support developing and updating evidence-based protocols and clinical guidelines and it will identify gaps in our scientific knowledge and therefore can give direction to future research on calcific and non-calcific RC-tendinosis.

2. Methods

2.1. Search strategy

This study was part of a literature study concentrating on evidence for effectiveness of non-surgical and surgical interventions for SIS. A search of relevant studies was performed in the Cochrane Library, PubMed, Embase, Pedro and Cinahl up to October 2010. Keywords related to the disorder and interventions were included in the literature search. See Appendix I for the complete search strategy.

2.2. Inclusion criteria

Systematic reviews and RCTs were included if they fulfilled all of the following criteria: (a) patients with SIS were included, (b) SIS was not caused by an acute trauma or any systemic disease as described in the definition of CANS, (c) an intervention for treating SIS was evaluated, (d) results on pain, function or recovery were reported, and (e) a follow-up period of at least two weeks was reported. There were no language restrictions.

ESWT can be subdivided in low-, medium- and high-energy extracorporeal shockwaves.(Albert et al., 2007) There is no universal agreement concerning the thresholds of these subdivisions. For the present study, we defined shockwaves $\leq$0.11 mJ/mm^2 as low-ESWT, between 0.12 and 0.28 mJ/mm^2 as medium-ESWT, and $>$0.28 mJ/mm^2 as high-ESWT (Albert et al., 2007; Loew et al., 1999).

2.3. Study selection

Two reviewers (BH, LG) independently applied the inclusion criteria to select potentially relevant studies from the title, abstracts and full-text articles respectively. A consensus method was used to solve disagreements concerning inclusion of studies, and a third reviewer (B) was consulted if disagreement persisted.

Table 1
Methodological quality assessment: sources of risk bias.

A.	1. Was the method of randomization adequate?
B.	2. Was the treatment allocation concealed?
C.	Was knowledge of the allocated interventions adequately prevented during the study?
	3. Was the patient blinded to the intervention?
	4. Was the care provider blinded to the intervention?
	5. Was the outcome assessor blinded to the intervention?
D.	Were incomplete outcome data adequately addressed?
	6. Was the drop-out rate described and acceptable?
	7. Were all randomized participants analysed in the group to which they were allocated?
E.	8. Are reports of the study free of suggestion of selective outcome reporting?
F.	Other sources of potential bias:
	9. Were the groups similar at baseline regarding the most important prognostic indicators?
	10. Were co-interventions avoided or similar?
	11. Was the compliance acceptable in all groups?
	12. Was the timing of the outcome assessment similar in all groups?

2.4. Categorization of the relevant literature

Relevant articles are categorized as follows: *Systematic reviews* describe all (Cochrane) reviews; *Recent RCTs* contains all RCTs published after the search date of the systematic review on the same intervention; *Additional RCTs* describes all RCTs concerning an intervention that has not yet been described in a systematic review.

2.5. Data extraction

Two authors (LG, RS/BH) independently extracted the data from the included articles. A consensus procedure was used to solve any disagreement between the authors. Results were reported in short-term ($\leq$3 months), mid-term (4–6 months), and long-term ($>$6 months).

2.6. Methodological quality assessment

Two reviewers (LG, MR) independently assessed the methodological quality of each RCT using the 12 quality criteria of Furlan et al. (2008) (Table 1). Each item was scored as "yes", "no", or "don't know/unsure/unclear". 'High-quality' was defined as a "yes" score of $\geq$50%. A consensus procedure was used to solve disagreement between the reviewers.

2.7. Data synthesis

A quantitative analysis of the studies was not possible due to heterogeneity of the outcome measures. Therefore, we summarized the results using a best-evidence synthesis (van Tulder et al., 2003).

The article was included in the best-evidence synthesis only if a comparison was made between the groups (e.g. treatment versus placebo, control or another treatment) and the level of significance was reported. The results of the study were labeled 'significant' if 1 of the 3 outcome measures on pain, function, or recovery reported significant results.

The level of evidence was ranked as follows:

1. Strong evidence for effectiveness: consistently[1] positive (significant) findings within multiple high-quality RCTs.
2. Moderate evidence for effectiveness: consistently[1] positive (significant) findings within multiple low-quality RCTs and/or one high-quality RCT.
3. Limited evidence for effectiveness: positive (significant) findings within one low-quality RCT.
4. Conflicting evidence for effectiveness: provided by conflicting (significant) findings in the RCTs ($<$75% of the studies reported consistent findings).
5. No evidence found in favour of the effectiveness of the intervention: RCT(s) available, but no (significant) differences between intervention and control groups were reported.
6. No systematic review or RCT found.

3. Results

3.1. Characteristics of the included studies

The initial literature search resulted in 5 systematic reviews from the Cochrane Library. Via PubMed 5 reviews and 159 RCTs, via

[1] $\geq$75% of the trials reported the same findings.

Embase 21 reviews and 202 RCTs, via Cinahl 344 reviews/RCTs, and via Pedro 7 reviews and 28 RCTs were found. Finally, no (Cochrane) reviews and 17 additional RCTs (14 via PubMed, 3 via Embase, 0 via Cinahl or Pedro) were included: 16 studied ESWT (10 for calcific and 6 for non-calcific tendinosis) and one studied Radial Shock-Wave Therapy (RSWT) for calicific tendinosis. RSWT is pneumatically generated with low- or medium-energy shockwaves (Cacchio et al., 2006) and therefore should have a lower peak-pressure and longer rise-time than ESWT. Further, the focal point is centred on the tip of the applicator instead of on the target zone, as is done in ESWT. Therefore, it is supposed to be less painful, of less risk and should target the calcification more effectively (Haake et al., 2002).

The characteristics of the studies are described in Appendix II.

3.2. Methodological quality

Of the 17 RCTs, 10 were classified as high-quality and 7 as low-quality (Table 2) by using the list of Furlan et al. (2009) The most prevalent methodological flaws were ‘care giver’ (i.e. the one who provides the intervention) not blinded’ (65%), and ‘no intention-to-treat analysis’ (35%).

3.2.1. Effectiveness of ESWT and RSWT to treat calcific and non-calcific RC-tendinosis

Tables 3 and 4 show the evidence for effectiveness we found in this study.

4. ESWT for calcific RC-tendinosis

4.1. High-ESWT versus placebo

A high-quality study (Gerdesmeyer et al., 2003) ($n = 96$) compared high-ESWT (EFD: 0.32 mJ/mm^2) to placebo for calcific supraspinatus tendinosis. At 3, 6, and 12 months follow-up, there were significant between-group differences in favour of the treatment group on pain, the total Constant Score, and on calcific deposit size (mm^2). See Appendix II for the exact data.

A low-quality study (Hsu et al., 2008) ($n = 46$) compared high-ESWT (EFD: 0.55 mJ/mm^2) to placebo for calcifying shoulder tendinosis. The treatment group showed significant decrease on pain and the Constant score compared to the sham group at 3, 6 and 12 months follow-up. The calcium deposit width reduction was bigger in the treatment group at 12 months, although no statistical comparisons were made between the groups.

In conclusion, there is moderate evidence for effectiveness of ESWT compared with placebo in the short-, mid- and long-term.

4.2. High-ESWT versus no treatment

A low-quality RCT (Loew et al., 1999) ($n = 80$) studied high-ESWT-1-session versus high-ESWT-2-sessions versus no treatment for calcific shoulder tendinosis. There were no baseline differences on the Constant score; at 3 months follow-up significant higher Constant scores for the ESWT groups (63.7 (14.6) (mean (SD)) (high-ESWT-1-session), 68.5 (13.1) (high-ESWT-2-sessions), 47.8 (11.4) (no treatment)) was found.

There is limited evidence for the effectiveness of high-ESWT (1 session and 2 sessions) compared to no treatment in the short-term.

4.3. High-ESWT: one versus two sessions

One low-quality RCT (Loew et al., 1999) studied effectiveness of high-ESWT-1-session versus high-ESWT-2-sessions. Significantly better improvement of radiological disappearance or disintegration

Table 2
Methodological quality scores of the included recent and additional RCTs.

Reference	Adequate randomization?	Allocation concealment?	Blinding? Patients?	Blinding? Caregiver?	Blinding? Outcome assessors?	Incomplete outcome data addressed? Dropouts?	Incomplete outcome data? ITT analysis?	Free of Suggestions of selective outcome reporting?	Similarity of baseline characteristics?	Co-interventions avoided or similar?	Compliance acceptable in all groups?	Timing of the outcome assessment similar?	Score maximum	Score study	Percentage
Peters et al. (2004)	+	?	+	+	+	+	+	+	?	?	+	+	12	9	75%
Gerdesmeyer et al. (2003)	+	+	+	–	+	+	–	+	?	+	+	+	12	9	75%
Haake et al. (2002)	+	+	+	–	+	+	–	+	?	+	+	+	12	9	75%
Albert et al. (2007)	+	–	+	?	–	+	+	+	+	+	+	–	12	8	67%
Cacchio et al. (2006)	+	?	+	–	+	+	+	+	+	?	?	+	12	8	67%
Schofer et al. (2009)	+	?	+	+	+	+	–	+	–	?	?	+	12	7	58%
Pan et al. (2003)	+	?	–	–	–	+	+	+	+	?	+	+	12	7	58%
Speed et al. (2002)	?	?	?	?	?	+	+	+	+	+	+	+	12	7	58%
Schmitt et al. (2001)	+	?	+	–	+	+	+	+	?	?	?	+	12	7	58%
Gross et al. (2002)	+	?	–	–	+	+	–	+	?	?	+	+	12	6	55%
Krasny et al. (2005)	+	?	–	–	+	+	+	+	?	?	n.a.	–	11	5	45%
Schmitt et al. (2002)	?	?	–	?	?	+	–	+	+	?	+	+	12	5	42%
Sabeti-Aschraf et al. (2005)	?	?	+	–	?	+	+	+	?	?	?	+	12	5	42%
Hsu et al. (2008)	–	?	+	–	+	?	?	+	?	?	?	+	12	4	33%
Perlick et al. (2003)	?	?	?	–	?	+	+	+	?	?	?	+	12	4	33%
Loew et al. (1999)	?	?	?	?	?	+	–	+	?	?	?	+	12	3	25%
Melegati et al. (2000)	?	?	–	–	?	?	?	+	?	?	?	+	12	2	17%

+, Yes; –, no; ?, unclear/unsure; n.a., not applicable (in a non-time intervention, such as surgery, compliance is not an issue); ITT, intention-to-treat.

Table 3
CANS: Evidence for the effectiveness of Extracorporeal Shock-Wave Therapy (ESWT) for calcific and non-calcific rotator cuff tendinitis.

		Calcific rotator cuff tendinitis	Non-calcific rotator cuff tendinitis
ESWT	High-ESWT	√[a,b,c,d,e,f,g,h]	0
	Medium-ESWT	0	0
	Low-ESWT	0	0
	Other	√[i]	

√, Strong or moderate evidence found; 0, RCT(s) found, but only limited, conflicting or no evidence for effectiveness of interventions was found; empty cells: no RCTs or reviews found.
[a]moderate evidence: high-ESWT* vs. placebo.
[d]strong evidence: high-ESWT* vs. low-ESWT.
[g]moderate evidence: high-ESWT: focus on calcific deposit* vs. focus on tuberculum major.
Mid-term:
[b]moderate evidence: high-ESWT* vs. placebo
[e]moderate evidence: high-ESWT* vs. low-ESWT
[i]moderate evidence: RSWT* vs. placebo
Long-term:
[c]moderate evidence: high-ESWT* vs. placebo
[f]moderate evidence: high-ESWT* vs. low-ESWT
[h]moderate evidence: high-ESWT: focus on calcific deposit* vs. focus on tuberculum major
*In favour of.

of calcium deposits was found in the 2-session group (77%) versus the 1-session group (47%) at 6 months follow-up.

There is limited evidence for the effectiveness of 2-sessions high-ESWT compared to 1-session high-ESWT in the mid-term.

4.4. High-ESWT versus low-ESWT

One high-quality RCT (Albert et al., 2007) ($n = 80$) compared high-ESWT (max 0.45 mJ/mm^2) to low-ESWT (0.02–0.06 mJ/mm^2) for calcific RC-tendinosis. Significant between-group results were found at 3 months follow-up on the Constant score in favour of the high-ESWT group (mean difference: 8.0 (95% CI 0.9–15.1)); no significant differences were found on pain.

Another high-quality study (Gerdesmeyer et al., 2003) ($n = 96$) compared high-ESWT (EFD: 0.32 mJ/mm^2) to low-ESWT (0.08 mJ/mm^2) to treat calcific supraspinatus tendinosis. At 3, 6, and 12 months follow-up significant differences were found in favour of the high-ESWT group on pain (between-group mean differences (95% CI) at 3, 6, and 12 months, respectively: 32.3 (0.5–1.3), 3.1 (2.5–4.3), 3.0 (2.3–3.7)), the total Constant Score (−9.6 (−15.8 to −3.4), −16.0 (−22.9 to −10.8), −13.9 (−19.7 to −8.3)), and on calcific deposit size (mm^2) (72.6 (8.2–141.1), 75.1 (9.0–144.3), 70.7 (1.9–139.5)).

There is strong evidence that high-ESWT is more effective for SIS than low-ESWT in the short-term and moderate evidence for mid- and long-term.

4.5. High-ESWT versus medium-ESWT

One low-quality RCT (Perlick et al., 2003) ($n = 80$) studied high-ESWT (0.42 mJ/mm^2) versus medium-ESWT (0.23 mJ/mm^2) for calcific shoulder tendinosis. No significant differences between the groups were found on the Constant score at 3 and 12 months follow-up. For pain and ROM no comparisons between the groups were made.

Another high-quality RCT (Peters et al., 2004) ($n = 61$) compared the effectiveness of high-ESWT (EFD: 0.44 mJ/mm^2) to medium-ESWT (0.15 mJ/mm^2) and placebo for calcific shoulder tendinosis. Six months after the last treatment recurrence of pain was lower in the high-ESWT group than in the medium-ESWT or the placebo group (0% versus 87% versus 100% respectively); also 'no calcification' was lowest in the high-ESWT group (100%) versus 0% in both the medium-ESWT and placebo group. However, no statistical comparisons between the groups were made.

Therefore, no evidence was found for the effectiveness of high-ESWT versus medium-ESWT in the short- and long-term.

4.6. High-ESWT: focus calcific deposit versus focus tuberculum majus

One high-quality RCT (Haake et al., 2002) ($n = 50$) compared high-ESWT (0.78 mJ/mm^2) focusing at the calcific deposit (focus-CD) to focusing at the tuberculum majus (focus-TM) for calcific supraspinatus tendinosis. At 12 weeks significant differences were found in favour of ESWT focus-CD on pain during activity, the Constant scores and improvement scores. At 1-year follow-up the results remain significant in favour of the ESWT focus-CD group on

Table 4
CANS: Evidence for the effectiveness of Extracorporeal Shock-Wave Therapy (ESWT) for calcific and non-calcific rotator cuff tendinitis.

ESWT for calcific tendinitis		ESWT for non-calcific tendinitis	
►High-ESWT* vs. placebo:		►High-ESWT 0.78 vs. 0.33 mJ/mm^2:	
Short-term	++	Short-term	NE
Mid-term	++	Long-term	NE
Long-term	++		
►High-ESWT* vs. no treatment:		►High-ESWT vs. placebo:	
Short-term	+	Long-term	NE
►ESWT: high 1 session vs. 2 sessions*:		►Low-ESWT vs. placebo:	
Mid-term	+	Short-term	NE
►High-ESWT* vs. low-ESWT:		►Low-ESWT vs. radiotherapy:	
Short-term	+++	Short-term	NE
Mid-term	++	Long-term	NE
Long-term	++		
►High-ESWT vs. medium-ESWT:		►Medium-ESWT vs. low-ESWT:	
Short-term	NE	Short-term	NE
Long-term	NE	Mid-term	NE
►High-ESWT: focus on calcific deposit* vs. focus on tuberculum major:		►Medium-ESWT plus kinesitherapy* vs. kinesitherapy only	
Short-term	++	Short-term	+
Long-term	++		
►High-ESWT vs. high-ESWT plus Needling* Mid-term		►Medium-ESWT plus kinesitherapy* vs. controls:	
►High-ESWT* vs. TENS Short-term	+	Short-term	+
►Low-ESWT vs. no treatment: Short-term	+		
►Low-ESWT low point of tenderness by palpation vs. tenderness computer- assisted*:	NE		
Short-term	+		
RSWT for calcific tendinitis			
►RSWT* vs. placebo:			
Short-term	++		
Mid-term	++		

+, limited evidence found; ++, moderate evidence found; +++, strong evidence found; ±, conflicting evidence for effectiveness; NE, no evidence found for effectiveness of the treatment: RCT(s) available, but no differences between intervention and control groups were found.
*, in favour of.
vs., Versus; ESWT, Extracorporeal Shock-Wave Therapy; RSWT, Radial Shock-Wave Therapy; TENS, Transcutaneous electrical nerve stimulation.

these outcome measures. On pain during rest no significant differences at 12 weeks follow-up and significant differences were found in favour of ESWT focus-CD at long-term.

There is moderate evidence that high-ESWT focus-CD is more effective than high-ESWT focus-TM in the short- and long-term.

4.7. High-ESWT versus high-ESWT plus needling

One low-quality RCT (Krasny et al., 2005) ($n = 80$) studied ultrasound-guided needling as add-on treatment versus high-ESWT (0.36 mJ/mm^2) for calcifying supraspinatus tendinosis. There were no significant differences on the Constant score between the groups after a mean follow-up of 4.1 months. Significantly more patients in the ESWT plus needling group showed elimination of the calcific deposits compared to the ESWT only group (60% versus 32.5% respectively).

There is limited evidence for the effectiveness of high-ESWT plus ultrasound-guided needling compared to high-ESWT in the mid-term.

4.8. High-ESWT versus TENS (Transcutaneous electrical nerve stimulation)

One low-quality trial (Pan et al., 2003) ($n = 63$) compared high-ESWT (0.26–0.32 mJ/mm^2) to TENS to treat calcific shoulder tendinosis. At 12 weeks follow-up the mean differences between the groups were significantly higher in favour of the ESWT group on pain (ESWT: −4.08 (2.59) (mean (sd)) (95% CI −8.00 to 3.00) versus TENS: −1.74 (2.20) (95% CI −5.50 to 2.00)), the constant score (28.31 (13.10) (95% CI −4.00 to 51.00) versus 11.86 (13.32)(95% CI −6.00 to 54.00)) and on improvement of the size of calcification (mm) (4.39 (3.76) (95% CI −1.45 to 0.17) versus 1.65 (2.83) (95% CI −0.90 to 0.10)).

There is limited evidence for the effectiveness of high-ESWT compared to TENS in the short-term.

4.9. Low-ESWT versus no treatment

One low-quality RCT (Loew et al., 1999) ($n = 80$) compared low-ESWT to no treatment of calcific RC-tendinosis. No significant differences between the groups were found on the Constant score at 3 months follow-up.

There is no evidence for the effectiveness of low-ESWT compared to no treatment in the short-term.

4.10. Low-ESWT: point of tenderness by palpation versus computer-assisted

One low-quality RCT (Sabeti-Aschraf et al., 2005) ($n = 50$) studied the effectiveness of low-ESWT in patients with calcific RC-tendinosis while finding the point of maximum tenderness using palpation (Palpation) versus using a computer-assisted navigation device (computer-navigation). For pain and the constant score the computer-navigation revealed significantly better results than palpation at 12 weeks follow-up. The exact scores are reported in Appendix II.

There is limited evidence that for low-ESWT using Computer-Navigation is more effective than Palpation in the short-term.

5. RSWT for calcific RC-tendinosis

5.1. RSWT versus placebo

One high-quality RCT (Cacchio et al., 2006) ($n = 90$) compared RSWT (0.10 mJ/mm^2) to placebo for calcific RC-tendinosis. Significant differences were found on the Los Angeles Shoulder Rating Scale and the UCLA score in favour of the RSWT group at 4 weeks and 6 months follow-up. Exact data are reported in the data extraction (Appendix II). No significant differences on function were found.

There is moderate evidence for the effectiveness of RSWT compared to placebo in the short- and mid-term.

6. ESWT for non-calcific RC-tendinosis

6.1. High-ESWT: 0.78 mJ/mm^2 vs 0.33 mJ/mm^2

One high-quality RCT (Schofer et al., 2009) compared two different energy flux densities of ESWT: 0.78 versus 0.33 mJ/mm^2 to treat patients with non-calcific tendinopathy. According to the classification we used in this paper for low-, mid- and high-ESWT (Loew et al., 1999; Albert et al., 2007), these densities are both classified as high-ESWT. No significant differences were found between the groups on pain at rest, pain during activity, the Constant Score or improvement at 3 months and 1-year follow-up.

Hence, there is no evidence for effectiveness of 0.78 vs 0.33 mJ/mm^2 for non-calcific tendinopathy in the short- and the long-term.

6.2. High-ESWT versus placebo

One low-quality RCT (Schmitt et al., 2002) ($n = 40$) compared high-ESWT to placebo for supraspinatus tendinosis. No significant between-group differences were found on pain in rest or activity, the Constant score or subjective improvement score after 1-year.

There is no evidence for the effectiveness of high-ESWT compared to placebo in patients with supraspinatus tendinosis in the long-term.

6.3. Low-ESWT versus placebo

A high-quality study (Schmitt et al., 2001) ($n = 40$) compared low-ESWT to placebo for supraspinatus tendinosis. At 12 weeks follow-up no significant between-group differences were found on pain in rest or activity, the Constant score, or improvement.

There is no evidence for the effectiveness of low-ESWT compared to placebo for supraspinatus tendinosis in the short-term.

6.4. Low-ESWT versus radiotherapy

A high-quality RCT (Gross et al., 2002) ($n = 30$) compared low-ESWT (EFD: 0.11 mJ/mm^2) to X-ray radiation treatment (6×0.5 Gy) for supraspinatus tendinosis. No significant between-group differences were found on pain during rest and activity, the Constant score, or subjective improvement at 12 and 52 weeks follow-up.

There is no evidence for the effectiveness of EWT compared to radiotherapy in the short and long-term.

6.5. Medium-ESWT versus low-ESWT

One high-quality study (Speed et al., 2002) ($n = 74$) compared medium- to low-ESWT for non-calcific RC-tendinosis. At 3 and 6 months follow-up, no significant between-group differences were found on night pain or the SPADI score.

There is no evidence for the effectiveness of medium or low-ESWT when compared to each other in the short and mid-term.

6.6. Medium-ESWT plus kinesitherapy versus kinesitherapy versus control

A low-quality RCT (Melegati et al., 2000) ($n = 90$) ($n = 60$) compared three treatment groups: medium-ESWT sequently followed by kinesitherapy (group B) versus only kinesitherapy (i.e. the following exercises: Codman, capsular stretching, isometric for the rotator and the deltoid muscles, and elastic resistance for the rotators, deltoid and trapezius muscles) (group A) versus controls (postural hygiene and joint economy suggestions) (group C) for non-calcific SIS. After 80 days, significant differences on the Constant score were found: group B scored 27.95% and 80.41% better than groups A and C, respectively.

There is limited evidence that medium-ESWT plus kinesitherapy is more effective than kinesitherapy only or controls for treating SIS in the short-term.

7. Discussion

ESWT has been suggested as a treatment alternative for calcific and non-calcific RC-tendinosis, which may decrease the need for surgery. We studied the evidence for effectiveness of this treatment.

7.1. Calcific RC-tendinosis

Strong evidence was found for effectiveness in favour of high-ESWT compared to low-ESWT for calcific RC-tendinosis in the short-term. Moderate evidence was found in favour of high-ESWT in the short-, mid- and long-term when compared to placebo, and in the mid- and long-term when compared to low-ESWT. Moreover, high-ESWT was more effective (moderate evidence) with focus on calcific deposit instead of focus on tuberculum major in the short- and long-term. RSWT was more effective (moderate evidence) than placebo in the mid-term.

7.2. Non-calcific RC-tendinosis

The 6 included RCTs that studied effectiveness of ESWT treating non-calcific RC-tendinosis did not reveal strong or moderate evidence. Only limited or no evidence for their efficacy is available. Only two small studies ($n = 40$ for both studies) with non-calcific RC-tendinosis of the shoulder focused on high-ESWT. One RCT compared two types of high-ESWT and the other RCT compared high-ESWT to placebo. The statistical power of these studies may have been too low to reveal significant differences. All other studies concentrated on low or medium-ESWT to treat non-calcific RC-tendinosis and no evidence for effectiveness was found. Bearing in mind that only high-ESWT yielded positive findings for calcific tendinosis, future research on the effectiveness of ESWT to treat non-calcific RC-tendinosis should concentrate on high-ESWT.

According to our findings, high-ESWT is effective to treat patients with calcific RC-tendinosis. However, the mechanism of actions remains unknown. Resorption of the calcification in the tendon and reactive hypervascularization have been proposed (Loew et al., 1995). In other studies, release of substance P and prostaglandin E2 in the rabbit femur (Maier et al., 2003), decrease of calcitonin gene-related peptide (CGRP) immunoreactivity in dorsal root ganglion neurons in the skin of rats (Takahashi et al., 2003), and selective loss of unmyelinated nerve fibres (Hausdorf et al., 2008) after ESWT have been found. Substance P, CGRP (Schmitz and DePace, 2009) and selective destruction of unmyelinated nerve fibres within the focal zone of the shockwave (Hausdorf et al., 2008) might contribute to the analgetic working mechanism of ESWT. More research on the mechanism of ESWT is required.

The present review has some limitations. Because of the heterogeneity of the trials, we refrained from statistical pooling of the results of the individual trials. A single-point estimate of the effect of the interventions included for calcific and non-calcific RC-tendinosis would probably not do justice to the differences between the trials regarding patient characteristics, interventions and outcome measures. The use of a best-evidence synthesis is a next best solution and a transparent method that is commonly applied in the field of musculoskeletal disorders when statistical pooling is not feasible or clinically viable (van Tulder et al., 2003). Secondly, only 56% of the total number of included RCTs was of high-quality. More high-quality RCTs are clearly needed in this field.

In conclusion, high-ESWT is effective (strong and moderate evidence) to treat calcific RC-tendinosis in the short, mid and long-term. Focus on the calcific deposit is more effective (moderate evidence) than focus on the tuberculum majus. Also RSWT seems to be a promising modality (moderate evidence) to treat this disorder.

For non-calcific RC-tendinosis, only limited evidence was found in favour of medium-ESWT plus kinesitherapy compared to kinesitherapy alone or controls in the short-term. Further, no evidence in favour of low, mid or high-ESWT compared to placebo, each other, or other treatment was found for non-calcific RC-tendinosis.

Therefore, this review presents evidence for effectiveness of high-ESWT for calcific RC-tendinosis, but no evidence for effectiveness of ESWT to treat non-calcific RC-tendinosis.

Acknowledgement

We thank Manon Randsdorp (MR) for her participation in the quality assessment.

Appendix I. Search strategy

PubMed

SIS – “shoulder impingement syndrome”[mh] OR “rotator cuff”[mh] OR “rotator cuff” OR (subacrom* AND impingement) OR (shoulder AND impingement) OR ((shoulder OR “shoulder pain”[mh] OR supraspinatus OR supraspinatus OR infraspinatus OR infraspinatus OR subscapularis OR subscapularis OR “teres minor”) AND (tendinopathy[mh:noexp] OR tenovaginitis OR tendovaginitis OR tendinit* OR tendonitis OR tenosynovitis OR tendinos* OR bursitis[mh:noexp])).

Therapy – (randomized controlled trial[Publication Type] OR (randomized[Title/Abstract] AND controlled[Title/Abstract] AND trial[Title/Abstract])).

Systematic reviews – ((meta-analysis [pt] OR meta-analysis [tw] OR metanalysis [tw]) OR ((review [pt] OR guideline [pt] OR consensus [ti] OR guideline* [ti] OR literature [ti] OR overview [ti] OR review [ti]) AND ((Cochrane [tw] OR Medline [tw] OR CINAHL [tw] OR (National [tw] AND Library [tw])) OR (handsearch* [tw] OR search* [tw] OR searching [tw]) AND (hand [tw] OR manual [tw] OR electronic [tw] OR bibliographi* [tw] OR database* OR (Cochrane [tw] OR Medline [tw] OR CINAHL [tw] OR (National [tw] AND Library [tw]))))) OR ((synthesis [ti] OR overview [ti] OR review [ti] OR survey [ti]) AND (systematic [ti] OR critical [ti] OR methodologic [ti] OR quantitative [ti] OR qualitative [ti] OR literature [ti] OR evidence [ti] OR evidence-based [ti]))) BUTNOT (case* [ti] OR report [ti] OR editorial [pt] OR comment [pt] OR letter [pt]).

RCTs – (randomized controlled trial [pt] OR controlled clinical trial [pt] OR randomized controlled trials [mh] OR random allocation [mh] OR double-blind method [mh] OR single-blind method [mh] OR clinical trial [pt] OR clinical trials [mh] OR “clinical trial”

[tw] OR ((singl* [tw] OR doubl* [tw] OR trebl* [tw] OR tripl* [tw]) AND (mask* [tw] OR blind* [tw])) OR "latin square" [tw] OR placebos [mh] OR placebo* [tw] OR random* [tw] OR research design [mh:noexp] OR comparative study [mh] OR evaluation studies [mh] OR follow-up studies [mh] OR prospective studies [mh] OR cross-over studies [mh] OR control* [tw] OR prospectiv* [tw] OR volunteer* [tw]) NOT (animal [mh] NOT human [mh]).

Embase

SIS – 'shoulder impingement syndrome'/OR ((shoulder/OR shoulder) AND impingement) OR 'rotator cuff'/OR 'rotator cuff' OR (subacrom* AND impingement) OR ((shoulder/OR shoulder OR supraspinatus OR supraspinatus OR infraspinatus OR infraspinatus OR subscapularis OR subscapularis OR 'teres minor') AND (tendinopathy OR tendovaginitis OR tendovaginitis/or tendinit* OR tendonitis OR tendinitis/OR tenosynovitis/OR tendinos* OR bursitis/)).

Therapy – 'randomized controlled trial':it OR (randomized:ti,ab AND controlled:ti,ab AND trial:ti,ab).

Systematic reviews – ('review'/exp AND (medline:ti,ab OR medlars:ti,ab OR embase:ti,ab OR pubmed:ti,ab) OR scisearch:ti,ab OR psychlit:ti,ab OR psyclit:ti,ab OR psycinfo:ti,ab OR pyschinfo:-ti,ab OR cinahl:ti,ab OR 'hand search':ti,ab OR 'manual search':ti,ab OR 'electric database':ti,ab OR 'bibliographic database':ti,ab OR 'pooled analysis':ti,ab OR 'pooled analyses':ti,ab OR pooling:ti,ab OR peto:ti,ab OR dersimonian:ti,ab OR 'fixed effect':ti,ab OR 'mantel haenszel':ti,ab OR 'retracted article':ti,ab) OR ('meta-analysis'/exp OR 'meta-analysis' OR 'meta-analysis' OR 'meta-analyses':ti,ab OR 'meta analyses':ti,ab OR 'systematic review':ti,ab OR 'systematic overview':ti,ab OR 'quantitative review':ti,ab OR 'quantitativ overview':ti,ab OR 'methodologic review':ti,ab OR 'methodologic overview':ti,ab OR 'integrative research review':ti,ab OR 'research integration':ti,ab OR 'quantitative synthesis':ti,ab).

RCTs – ('controlled clinical trial'/exp OR 'randomized controlled trial':ti OR 'controlled clinical trial':it OR 'randomization'/OR 'double-blind procedure'/OR 'single-blind procedure'/OR 'crossover procedure'/OR 'clinical trial':it OR (('clinical trial' OR (singl* OR doubl* OR tripl*)) AND (mask* OR blind*)) OR ('Latin square design'/ OR 'latin-square' OR 'latin-square') OR 'placebo'/OR placebo* OR 'random sample'/OR 'comperativestudy':it OR 'evaluation study':it OR evaluation/exp OR 'follow-up'/exp OR 'prospective study'/OR control* OR prospectiv* OR volunteer*) NOT (animals/exp NOT humans/exp).

Cinahl

SIS – (MH "Shoulder impingement syndrome") or (MH "rotator cuff")or "rotator cuff" or (subacrom* and impingement) or (((MH "shoulder") or (MH "shoulder joint") or shoulder) and impingement) or (((MH "shoulder") or (MH "shoulder joint") or shoulder or (MH "shoulder pain") or supraspinatus or supraspinatus or infraspinatus or infraspinatus or subscapularis or subscapularis or "teres minor") and ((MH "Tendinitis") or (MH "tenosynovitis") or tend* or tenovaginitis or tendovaginitis)).

Reviews – (MH "Systematic Review").

Clinical trials – (MH "Clinical Trials+").

Pedro

SIS – subacromial impingement syndrome, Rotator cuff syndrome, impingement syndrome.

Appendix II. Data extraction – RCTs.

Author	Treatment	Placebo	Control/comparison	Outcome measures and FU time	Results – statistical	Results – words
ESWT for calcific tendinitis of the rotator cuff						
High-ESWT vs. placebo						
Gerdesmeyer et al. (2003) Calcific tendinosis of the supraspinatus tendon	High-ESWT (1500 pulses 0.32 mJ/mm^2) ($n = 48$)	Sham ESWT ($n = 48$)		Pain (VAS)	No p-value given	ESWT[a] vs. placebo
						Baseline: 6.5 (1.3) (mean (SD)) vs. 5.6 (1.6)
						Mean change from baseline (95% CI):
						3 months: −5.0 (−5.7 to −4.2) vs. −1.8 (2.5 to −1.1)
					$p < 0.001$	Between-group difference (95% CI): 3.2 (2.2–4.2)
						6 months: −5.5 (−6.2 to −4.8) vs. −1.1 (−1.8 to −0.5)
					$p < 0.001$	Between-group difference (95% CI): 3.7 (2.7–4.7)
						12 months: −5.6 (−6.3 to −4.9) vs. −1.9 (−2.7 to −1.2)
					$p < 0.001$	Between-group difference (95% CI): 3.7 (2.7–4.7)
				Total Constant and Murley Score	No p-value given	ESWT[a] vs. placebo Baseline: 60 (11.0) (mean (SD)) vs. 64.2(12.8)
						Mean change from baseline (95% CI):
						3 months: 26.2 (22.3–30.2) vs. 9.8 (5.1–14.5)
					$p < 0.001$	Between-group difference (95% CI): −16.4 (−22.5 to −10.3)
						6 months: 31.0 (26.7–35.3) vs. 6.6 (1.4–11.8)
					$p < 0.001$	Between-group difference (95% CI): −24.4 (−31.0 to −17.8)
						12 months: 31.6 (27.3–36.0) vs. 13.7 (8.4–19.0)
					$p < 0.001$	Between-group difference: (95% CI): −17.9 (−24.7 to −11.1)

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Appendix (*continued*)

Author	Treatment	Placebo	Control/comparison	Outcome measures and FU time	Results – statistical	Results – words
				Calcific deposit size (mm^2)	No *p*-value given	ESWT[a] vs. placebo Baseline: 182 (135) (mean (SD)) vs. 128 (112) Mean change from baseline (95% CI): at 3 months: −128.9 (−170.0 to −87.7) vs.−30.3 (−53.7 to −7.0)
					$p < 0.001$	Between-group difference (95% CI): 98.6 (51.8–145.4) 6 months: −152.8 (−195.0 to −110.0) vs.−41.0 (−66.0 to −16.1)
					$p < 0.001$	Between-group difference (95% CI): 111.8 (63.2–160.5) 12 months: −162.2 (−204.0 to −120.0) vs.−46.8 (−74.3 to −19.3)
					$p < 0.001$	Between-group difference (95% CI): 115.4 (65.4–165.4)
Hsu et al. (2008) Calcifying tendinosis of the shoulder	High-ESWT EFD: 0.55 mJ/mm^2 ($n = 33$)	Sham ESWT ($n = 13$)		Pain (VAS) (12 months)	$p > 0.05$	Baseline: ESWT: 7.2 vs. sham: comparable (no exact data given)
					$p < 0.05$	3 months: ESWT[a]: 2.1 vs. sham: **no exact data given
					$p < 0.05$	6 months: ESWT[a]: 1.6 vs. sham: **no exact data given
					$p < 0.05$	12 months: ESWT[a]: 1.3 vs. sham: **no exact data given
					$p < 0.001$	3, 6, 12 months: within ESWT group[c]
					$p > 0.05$	3, 6, 12 months: within placebo group[c] **pain scores persisted at the same high level pretreatment level
				Constant score (12 months)	$p < 0.05$	Baseline: ESWT: 57.3 vs. sham: 56.2
					$p < 0.05$	3 months: ESWT[a]: 82.8 vs. sham: 54.3
					$p < 0.05$	6 months: ESWT[a]: 85 vs. sham: 56.8
					$p < 0.05$	12 months: ESWT[a]: 88 vs. sham: no exact data given (comparable to score at 6 months).
					$p < 0.001$	3, 6, 12 months: within ESWT group[c]
					$p > 0.05$	3, 6, 12 months: within placebo group[c]
				Calcium deposit width (AP radiographs)	$p < 0.001$	ESWT: 11.9 ± 5.4 mean (SD) from baseline to 5.5 ± 6.3 after treatment[c] vs.
					$p = 0.415$	Sham: 10.5 ± 6.4 from baseline to 9.8 ± 5.9 after treatment[c]
High-ESWT versus no treatment:						
Loew et al. (1999) Calcific tendinosis of the shoulder	High-ESWT EFD: 0.30 mJ/mm^2 (high), single session ($n = 20$)		control (no treatment) ($n = 20$)	Constant score (0–100)	Not significant (no *p*-value given)	Baseline: ESWT: 39.0 (11.8) (mean (SD)) vs. control: 44.5 (8.3)
					$p < 0.0001$	3 months: ESWT[a]: 63.7 (14.6) vs. control 47.8 (11.4)
Loew et al. (1999) Calcific tendinosis of the shoulder	High-ESWT: EFD: 0.30 mJ/mm^2 (high), two sessions ($n = 20$)		Control (no treatment) ($n = 20$)	Constant score (0–100)	Not significant (no *p*-value given)	Baseline: ESWT: 43.5 (13.1) (mean (SD)) vs. control: 44.5 (8.3)
					$p < 0.0001$	3 months: ESWT[a]: 68.5 (13.1) vs. control 47.8 (11.4)
High-ESWT: one session versus two sessions:						
Loew et al. (1999) Calcific tendinosis of the shoulder	ESWT:EFD: 0.3 mJ/mm^2 (high), 1 session ($n = 42$)		ESWT: EFD: 0.1 mJ/mm^2, 2 sessions ($n = 49$)	Pain relief (%)	$p > 0.05$	6 months: 1 session: 45% vs. 2 sessions: 53%
				Constant score (0–100)	$p > 0.05$	1 session: from baseline 49.3 (13.4) (mean (SD)) to 67.7 (17.8) at 6 months vs. 2 sessions: 44.4 (12.2) at baseline to 69.6 (19.8) at 6 months
				Improvement: radiological disappearance or disintegration of calcium deposits	$p = 0.046$	6 months: 1 session: 47% vs. 2 sessions[a]: 77%
High-ESWT vs. low-ESWT						
Albert et al. (2007) Calcific tendinosis of the rotator cuff	ESWT: EFD: max 0.45 mJ/mm^2 (high) ($n = 40$)		ESWT: EFD: 0.02 −0.06 mJ/mm^2 (low) ($n = 40$)	Constant score: Change in the mean total score (range 0–100)	$p = 0.026$	Change from baseline to 3 months after intervention: 12.5 (−20.7 to 47.5) (mean ((range)) vs. 4.5 (−24.4 to39.3) mean difference 8.0 (95% CI 0.9–15.1)
				Pain (VAS)	$p > 0.05$	

					Baseline: High-ESWT: 5.6 (0.4–9.7) vs. Low-ESWT: 5.6 (1.2–9.4)
				$p = 0.069$	3 months: −2.3 (−8.3 to 4.9) vs. −1.1 (−7.3 to 3.8) (95% CI −0.22 to 0.9)
Gerdesmeyer et al. (2003) Calcific tendinosis of the supraspinatus tendon	High-ESWT (1500 pulses 0.32 mJ/mm^2) ($n = 48$)	Low-ESWT (6000 pulses 0.08 mJ/mm^2) ($n = 48$)	Pain (VAS)	No p-value given	High vs. low-ESWT Baseline: 6.5 (1.3) (mean (SD)) vs. 5.7 (1.9) Mean change (95% CI) from baseline to follow-up
				$p < 0.001$	High[a] vs Low-ESWT: 3 months: −5.0 (−5.7 to −4.2) vs. −2.7 (3.3 to −2.1) Between-group difference (95% CI): 32.3 (0.5–1.3) 6 months: −5.5 (−6.2 to −4.8) vs. −2.4 (−3.1 to −1.7) Between-group difference (95% CI): 3.1 (2.5–4.3) 12 months: −5.6 (−6.3 to −4.9) vs. 2.6 (−3.2 to −1.9) Between-group difference (95% CI): 3.0 (2.3–3.7)
			Total Constant and Murley Score	No p-value given	High vs. Low-ESWT: Baseline: 60 (11.0) (mean (SD)) vs. 62.7 (14.0) Mean change (95% CI) from Baseline to follow-up
				$p = 0.003$	High[a] vs Low-ESWT: 3 months: 26.2 (22.3–30.2) vs. 16.6 (11.8–21.0)
				$p < 0.001$	Between-group difference (95% CI): −9.6 (−15.8 to −3.4) 6 months: 31.0 (26.7–35.3) vs. 15.0 (10.2–19.8) Between-group difference (95% CI): −16.0 (−22.9 to −10.8)
				$p < 0.01$	12 months: 31.6 (27.3–36.0) vs. 17.7 (13.2–22.3) Between-group difference (95% CI): −13.9 (−19.7 to −8.3)
			Calcific deposit size (mm^2)	No p-value given	High vs. Low-ESWT Baseline: 182 (135) (mean (SD)) vs. 195 (166) Mean change (95% CI) from baseline to follow-up
				$p = 0.03$	High vs. Low-ESWT: 3 Months: −128.9 (−170.0 to −87.7) vs.−56.3 (−106.7 to 5.8)
				$p = 0.03$	Between-group difference: (95% CI): 72.6 (8.2–141.1) 6 months: −152.8 (−195.0 to −110.0) vs.−77.7 (−130.0 to −24.9)
				$p = 0.04$	Between-group difference: (95% CI): 75.1 (9.0–144.3) 12 months: −162.2 (−204.0 to −120.0) vs.−91.5 (−148.0 to −35.1) Between-group difference: (95% CI): 70.7 (1.9–139.5)
High-ESWT vs. medium-ESWT					
Perlick et al. (2003) Calcific tendinosis of the shoulder	ESWT EFD: 0.23 mJ/mm^2 (medium) (n = 40)	ESWT: EFD: 0.42mJ/mm^2 (high) ($n = 40$)	Pain (max 15, VAS)	No p-value given	Baseline: Medium: 3.2 (2.7) (mean (SD)) vs. high: 4.2 (2.5) 3 months: Medium: 9.8 (3.1) vs. high: 11.2 (3.4) 12 months: Medium: 9.0 (3.7) vs. high: 10.5 (3.2)
			Development of the ROM subscore of the Constant and Murley score in the two groups	No p-value given	Baseline: Medium: 18.2 (7.4) vs. high: 19.5 (6.6) 3 months: Medium: 28.2 (8.5) vs. high: 31.1 (8.4) 12 months: Medium: 26.8 (9.2) vs. high: 29.3 (8.6)
			Constant score (0–100)	$p > 0.05$	Baseline: medium: 46.3 vs. high: 48.4 3 Months: medium: 69.2 (SD not given) vs. high: 76.4
				$p > 0.05$	12 Months: medium: 68.3 (SD not given) vs. high: 73.2
		Sham ESWT ($n = 29$)			High-ESWT vs. medium vs. placebo: 0% vs. 87% vs. 100%[c]

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Appendix (*continued*)

Author	Treatment	Placebo	Control/comparison	Outcome measures and FU time	Results – statistical	Results – words
Peters et al. (2004) Calcific tendinosis of the shoulder	High level ESWT EFD: 0.44 mJ/mm^2 ($n = 31$)		Medium level ESWT EFD: 0.15 mJ/mm^2 ($n = 30$)	Recurrence of pain (6 months after last treatment)		
				Residual calcification (6 months after last treatment)		High-ESWT vs. low-ESWT vs. placebo: 100% vs. 0% vs. 0% vs.[c]
High-ESWT: focus calcific deposit versus focus tuberculum majus						
Haake et al. (2002) Calcific tendinosis of the supraspinatus	ESWT: focus on calcific deposit EFD: 0.78 mJ/mm^2 (high) ($n = 25$)		ESWT: focus on tuberculum majus EFD: 0.78 mJ/mm^2 (high) ($n = 25$)	Pain during rest (Range 0–11)	Not significant (no *p*-value given)	Baseline: Treatment: 7.08 (2.74) (mean (SD)) vs. comparison: 7.17 (2.53) (95% CI −1.60 to 1.43)
					Not significant (no *p*-value given)	12 weeks: Treatment: 3.21 (2.86) vs. comparison: 4.74 (3.11) (95% CI −3.28 to 0.22)
					Significant (no *p*-value given)	1 year: treatment[b]: 1.48 (0.92) vs. comparison: 3.75 (2.91) (95% CI −3.50 to −1.04)
				Pain during activity (range 0–11)		Baseline: treatment: 8.56 (1.58) vs. comparison: 8.54 (1.91) (95% CI −0.99 to 1.03)
					Not significant (no *p*-value given)	12 Weeks: treatment[b]: 3.79 (2.67) vs. comparison: 6.65 (3.10) (95% CI −4.65 to −1.16)
					Significant (no *p*-value given)	1 Year: treatment[b]: 2.76 (1.92) vs. comparison: 6.04 (2.87) (95% CI −4.68 to −1.88)
				Constant score (range 0–100)	Significant (no *p*-value given)	Baseline: Treatment: 49.96 (10.87.3) vs. comparison: 47.17 (11.53) (95% CI −3.64 to 9.23)
					Not significant (no *p*-value given)	12 weeks: Treatment[b]: 104.59 (23.12) vs. comparison: 73.08 (29.44) (95% CI 16.99–47.03)
					Significant (no *p*-value given)	1 year: Treatment[b]: 116.24 (16.23) vs. comparison: 83.51 (26.40) (95% CI 20.19–45.27)
				Subjective improvement (%)	Significant (no *p*-value given)	12 weeks: Treatment[b]: 57.46 (32.18) vs. comparison: 31.74 (35.60) (95% CI −5.80 to 45.64)
					Significant	1 year: Treatment[b]: 81.36 (19.08) vs. comparison: 47.04 (36.50) (95% CI 17.68–50.96)
					Not significant	ESWT: 78.0 (27.8) vs. comparison: 63.3 (40.6) (95% CI −15 to 50)
High-ESWT vs. high-ESWT plus needling						
Krasny et al. (2005) Calcific supraspinatus tendonosis	High-ESWT plus Ultrasound-guided needling ($n = 40$)		High-ESWT only (200 impulses followed by 2500 pulses, EFD 0.36 mJ/mm^2) ($n = 40$)	Constant score (mean 4.1 months)	NS	No difference in proportion of improved shoulders between the 2 groups (no data given)
				Improvement: elimination of calcific deposits (radiographs) (mean 4.1 months)	$p = 0.024$	ESWT plus needling[b] vs. ESWT: 60% vs. 32.5%
				Improvement (subsequent surgery)		ESWT plus needling vs. ESWT: 20% vs. 45%
High-ESWT vs. TENS						
Pan et al. (2003) Calcific tendinosis of the shoulder	High-ESWT 2Hz 2000 shock waves, 2 sessions, 14 days apart 0.26–0.32 mJ/mm^2 ($n = 33$ shoulders)		TENS 3×/week 20 minutes for 4 weeks ($n = 30$ shoulders)	Pain (VAS) (range 0 −10)	$p = 0.027$	Mean of difference between week 2 and baseline evaluation: ESWT[b]: −1.85 (1.90) (mean(SD)) (95% CI −6.00 to 2.00) vs. TENS: −1.31 (2.31) (95% CI −10.00 to 0.50)

				$p = 0.001$	Mean of difference between week 4 and baseline evaluation: ESWT[b]: −3.00 (2.41) (95% CI 6.50−3.00) vs. TENS: −1.10 (1.94) (95% CI −5.50 to 2.00)
				$p = 0.000$	Mean of difference between week 12 and baseline evaluation: ESWT[b]: −4.08 (2.59) (95% CI −8.00 to 3.00) vs. TENS: −1.74 (2.20) (95% CI −5.50 to 2.00)
			Constant score (range 0−100)	$p = 0.000$	Mean of difference between week 2 and baseline evaluation: ESWT[b]: 13.79 (11.25) (95% CI −6.00 to 44.25) vs. TENS: 3.52 (6.73) (95% CI −1.00 to 24.00)
				$p = 0.000$	Mean of difference between week 4 and baseline evaluation: ESWT[b]: 24.21 (13.68) (95% CI −10.00 to 48.50) vs. TENS: 9.59 (9.62) (95% CI −2.00 to 40.00)
				$p = 0.000$	Mean of difference between week 12 and baseline evaluation: ESWT[b]: 28.31 (13.10) (95% CI −4.00 to 51.00) vs. TENS: 11.86 (13.32) (95% CI −6.00 to 54.00)
			Strength: MMT (no. of improved shoulders/ total no. of shoulders) (range 0−5)	NS	Mean of difference between week 2 and baseline evaluation: ESWT: 13/33 (39.4%) vs. TENS: 7/29 (24.1%)
				NS	Mean of difference between week 4 and baseline evaluation: ESWT: 21/33 (63.6%) vs. TENS: 15/29 (51.7%)
				NS	Mean of difference between week 12 and baseline evaluation: ESWT: 23/33 (69.7%) vs. TENS: 18/29 (62.1%)
			Improvement: size of calcification (mm)	NS	Mean of difference between week 2 and baseline evaluation: ESWT: 1.26 (3.71) (95% CI −1.20 to 0.58) vs. TENS: 0.25 (1.97) (95% CI −0.40 to 0.50)
				$p = 0.003$	Mean of difference between week 4 and baseline evaluation: ESWT[b]: 3.16 (4.09) (95% CI −1.42 to 0.48) vs. TENS: 0.75 (1.70) (95% CI −0.45 to 0.30)
				$p = 0.002$	Mean of difference between week 12 and baseline evaluation: ESWT[b]: 4.39 (3.76) (95% CI −1.45 to 0.17) vs. TENS: 1.65 (2.83) (95% CI −0.90 to 0.10)
			Improvement: type of calcification (no. of changed shoulders/ total no. of shoulders) (%)	$p = 0.000$	Mean of difference between week 2 and baseline evaluation: ESWT[b]: 23/33 (69.7) vs. TENS: 6/29 (20.7)
				$p = 0.001$	Mean of difference between week 4 and baseline evaluation: ESWT[b]: 20/33 (60.6) vs. TENS: 6/29 (20.7)
				$p = 0.001$	Mean of difference between week 12 and baseline evaluation: ESWT[b]: 16/33 (48.5) vs. TENS: 3/29 (10.3)
Low-ESWT vs. control					
Loew et al. (1999) Calcific tendinosis of the shoulder	Low-ESWT: EFD: 0.10 mJ/ mm^2 (low) ($n = 20$)	Control (no treatment) ($n = 20$)	Constant score (0−100)	Not significant (no p-value given)	Baseline: ESWT: 39.4 (11.2) (mean (SD)) vs. control: 44.5 (8.3)
				$p > 0.05$	3 Months: ESWT: 51.6 (20.1) vs. control 47.8 (11.4)
Low-ESWT: point of tenderness using palpation versus using computer-assisted navigation					
Sabeti-Aschraf et al. (2005) Calcific tendinosis of the rotator cuff	ESWT: 0.08 mJ/mm^2 point of max. tenderness by palpation ($n = 25$)	ESWT: 0.08 mJ/mm^2 Point of max. tenderness by computer-assisted navigation device ($n = 25$)	Pain (VAS) (range 0−100)	$p = 0.0236$	Comparison between groups from baseline to 12 weeks Follow-up: Palpation: from 68.36 (15.26) (mean (SD)) to 33.36 (20.05) vs.Computer-assisted[b]: from 65.96 (21.71) to 18.21 (21.32)[b]
			Constant and Murley Score	$p = 0.0208$	Palpation: from 55.64 (15.41) (mean (SD)) to 73.0 (16.25) vs. Computer-assisted[b]: from 49.4 (12.33) to 79.48 (15.10)[b]
RSWT					
Cacchio et al. (2006) Calcific tendinosis of the shoulder	RSWT 4 sessions at 1-week intervals, with 25,00 pulses per session, 0.10 mJ/mm^2 ($n = 25$)	4 sessions at 1-week intervals, total number of pulses: 25 ($n = 25$)	Los Angeles Shoulder Rating Scale (range 0 −35)	$p = 0.9144$	Baseline: RSWT: 10.25 (2.08) (mean (SD)) vs. control: 10.14 (1.96)
				$p = 0.0056$	4 Weeks: RSWT: 33.12 (2.94) vs. control 11.28 (2.82)
				$p = 0.0023$	6 Months: RSWT: 32.12 (3.02) vs. control: 10.57 (3.96)
			UCLA Shoulder Rating Scale Item: Pain (range 1−10)	$p = 0.8966$	Baseline: RSWT: 1.39 (0.97) vs. control: 1.04 (1.03)
				$p = 0.0044$	4 Weeks: RSWT: 7.90 (1.09) vs. control: 2.85 (2.03)
				$p = 0.0023$	6 Months: RSWT: 7.95 (0.92) vs. control: 2.64 (1.14)

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Appendix (*continued*)

Author	Treatment	Placebo	Control/comparison	Outcome measures and FU time	Results – statistical	Results – words
				ROM – active forward flexion (degrees)	$p = 0.2033$ $p = 0.0084$ $p = 0.0127$	Baseline: RSWT: 66.75 (15.41) vs. control: 68.14 (18.77) 4 Weeks: RSWT:134.35 (24.93) vs. control: 85.00 (32.45) 6 Months: RSWT: 152.00 (28.99) vs. control: 90.00 (26.15)
				Function (range 0–5)	$p = 0.4738$ $p = 0.0748$ $p = 0.163$	Baseline: RSWT: 2.10 (0.33) vs. control: 2.18 (0.45) 4 Weeks: RSWT: 4.48 (0.85) vs. control: 2.98 (1.90) 6 Months: RSWT: 4.50 (0.82) vs. control: 2.45 (1.61)
				Strength – forward flexion (range 0–5)	$p = 0.6590$ $p = 0.0067$ $p = 0.0045$	Baseline: RSWT: 3.49 (0.75) vs. control: 3.16 (0.32) 4 Weeks: RSWT: 4.98 (0.35 vs. control: 3.66 (0.95) 6 Months: RSWT: 4.85 (0.46) vs. control: 3.42 (0.95)
				Patient satisfaction (range 0–5)	$p = 0.7494$ $p = 0.0017$ $p = 0.0011$	Baseline: RSWT: 0.80 (0.50) vs. control: 0.84 (0.45) 4 Weeks: RSWT: 4.80 (1.02) vs. control: 1.70 (1.90) 6 Months: RSWT: 4.60 (1.03) vs. control: 1.05 (0.95)
ESWT for non-calcific tendinitis of the rotator cuff						
High-ESWT, 2 different energy flux densities						
Schofer et al. (2009) Non-calcific shoulder tendinopathy	High-ESWT-1 0.78 mJ/mm^2 ($n = 20$) Patients in both groups were treated with minimal 10 sessions physiotherapy plus 2 steroid injections and NSAIDs before treatment with ESWT		High-ESWT-2 0.33 mJ/mm^2 ($n = 20$)	Pain at rest (VAS)	$p = 0.006$ $p = 0.220$ $p = 0.899$	Baseline: ESWT-1: 5.65 (2.52) (mean (SD))vs ESWT-2: vs 3.445 (2.44) 3 Months: ESWT-1: 3.47 (3.29) vs ESWT-2: 2.30 (2.56) 1 Year: ESWT-1: 2.11 (2.71) vs ESWT-2: 2.00 (2.25)
				Pain during activity (VAS)	$p = 0.668$ $p = 0.720$ $p = 0.979$	Baseline:ESWT-1: 7.10 (2.47) (mean (SD)) vs ESWT-2: 7.40 (1.88) 3 Months:ESWT-1: 4.58 (3.60) vs ESWT-2: 4.20 (2.93) 1 year:ESWT-1: 3.53 (3.44) vs ESWT-2: 4.20 (2.93)
				Constant Score	$p = 0.691$ $p = 0.285$	Baseline:ESWT-1: 46.37 (22.47) (mean (SD)) vs ESWT-2: 49.06 (20.52) 3 Months:ESWT-1: 79.77 (35.47) vs ESWT-2: 67.89 (32.94) 1 Year:ESWT-1: 88.45 (31.97) vs ESWT-2: 75.45 (33.87)
				Improvement (%)	$p = 0.878$	3 Months:ESWT-1: 44.74 (38.60) (mean (SD)) vs ESWT-2: 46.50 (32.65) 1 Year:ESWT-1: 63.42 (37.46) vs ESWT-2: 63.44 (33.90)
High-ESWT vs. placebo						
Schmitt et al. (2002) Non-calcific supraspinatus tendinosis	High-ESWT 0.33 mJ/mm^2 ($n = 20$)	Sham ESWT ($n = 20$)		Pain during rest (VAS) (range 0–10)	$p > 0.05$ $p > 0.05$	Baseline: ESWT: 5.58 (1.9) (mean (SD)) vs. control: 6.00 (3.1) (95% CI −2.62 to 1.78) 1 Year: ESWT: 0.50 (1.7) vs. control: 0.44 (1.3) (95% CI −1.40 to 1.51)
				Pain during activity (VAS) (range 0–10)	$p > 0.05$ $p > 0.05$	Baseline: ESWT: 7.75 (1.3) vs. control: 8.55 (1.8) (95% CI −2.24 to 3.21) 1 Year: ESWT: 1.67 (2.7) vs. control: 1.33 (3.0) (95% CI −2.28 to 2.95)
				Constant score (range 0–100)	$p > 0.05$ $p > 0.05$	Baseline: ESWT: 41.27 (13.2) vs. control: 44.68 (13.5) (95% CI −14.99 to 8.16) 1 Year: ESWT: 106.36 (32.6) vs. control: 109.52 (18.7) (95% CI −28.62 to 22.31)
				Subjective improvement (%)	$p > 0.05$	1 Year: ESWT: 87.33 (17.0) vs. control: 86.67 (17.3) (95% CI −15.15 to 16.48)
Low-ESWT vs. placebo						
Schmitt et al. (2001) Non-calcific supraspinatus tendinosis	ESWT: 0.11 mJ/mm^2 ($n = 20$)	Sham ESWT ($n = 20$)		Pain during rest (VAS) (range 0–10)	$p > 0.05$	Baseline: ESWT: 5.35 (2.54) (mean (SD)) vs. control: 5.40 (3.00) (95% CI −1.73 to 1.83) 12 Weeks: ESWT: 2.30 (3.03) vs. control: 3.22 (2.82) (95% CI −1.01 to 2.85)
				Pain during activity (VAS) (range 0–10)	$p > 0.05$	Baseline: ESWT: 7.75 (1.48) vs. control: 7.95 (1.96) (95% CI −0.91 to 1.31) 12 Weeks: ESWT: 4.85 (3.07) vs. control: 6.11 (3.23) (95% CI −0.81 to 3.33)
				Constant score (range 0–100)	$p > 0.05$	Baseline: ESWT: 40.70 (13.29) vs. control: 42.20 (13.04) (95% CI −6.93 to 9.93) 12 Weeks: ESWT: 66.50 (37.92) vs. control: 64.39 (32.68) (95% CI −25.53 to 21.31)
				Subjective improvement (%)	$p > 0.05$	12 Weeks: ESWT: 40.00 (38.35) vs. control: 31.05 (31.43) (95% CI 31.77 to 13.87)

Low-ESWT vs. radiotherapy					
Gross et al. (2002) Non-calcific supraspinatus tendinosis	ESWT 3× 2000 pulses at 1-week interval, EFD: 0.11 mJ/mm^2 ($n=16$)	X-ray radiation treatment 6 × 0.5 Gy (5 times/week) ($n=14$)	Pain during rest (VAS) (range 1–10)	Not significant (no *p*-value given)	Baseline: ESWT: 5.3 (2.0) (mean (SD)) vs. comparison: 4.9 (2.3) (95% CI −2 to 2)
				Not significant	12 Weeks: ESWT: 1.8 (1.5) vs. comparison: 3.7 (2.5) (95% CI −3 to 0)
				Not significant	52 Weeks: ESWT: 1.5 (1.4) vs. comparison: 3.1 (3.2) (95% CI 0–0)
			Pain during activity (VAS) (range 1–10)	Not significant	Baseline: ESWT: 7.1 (1.3) vs. comparison: 4.9 (2.3) (95% CI −1 to 0)
				Not significant	12 Weeks: ESWT: 3.8 (2.3) vs. comparison: 5.6 (2.6) (95% CI −3 to 0)
				Not significant	52 Weeks: ESWT: 2.8 (2.6) vs. comparison: 3.0 (3.3) (95% CI −2 to 0)
			Constant score (range 0–100)	Not significant	Baseline: ESWT: 50.1 (12.1) vs. comparison: 47.6 (8.7) (95% CI −6 to 10)
				Not significant	12 Weeks: ESWT: 91.5 (26.0) vs. comparison: 79.5 (28.7) (95% CI −9 to 33)
				Not significant	52 Weeks: ESWT: 97.8 (21.3) vs. comparison: 87.4 (38.9) (95% CI −16 to 37)
			Subjective improvement (%)	Not significant	12 Weeks: ESWT: 65.9 (26.5) vs. comparison: 38.9 (29.4) (95% CI 5–50)
				Not significant	52 Weeks: ESWT: 78.0 (27.8) vs. comparison: 63.3 (40.6) (95% CI −15 to 50)
Medium-ESWT vs. low-ESWT					
Speed et al. (2002) Non-calcific tendinosis of the rotator cuff	ESWT EFD: 0.12 mJ/mm^2 (medium) ($n=34$)	ESWT: minimum EFD: 0.04 mJ/mm^2 (low) ($n=40$)	Night pain	Not significant (no *p*-value given)	Baseline: medium: 60.9 (24.6) (mean (SD)) (95% CI 5–100) vs. low 67.7 (25.7) (95% CI 3–98)
				Not significant (no *p*-value given)	3 Months: Medium: 38.1 (28.3) (95% CI 0–95) vs. low 39.3 (31.8) (95% CI 2–92)
				Not significant (no *p*-value given)	6 Months: Medium: 27.3 (26.9) (95% CI 0–82) vs. low 33.3 (32.3) (95% CI 0–98)
			SPADI (range 0–100)	Not significant (no *p*-value given)	Baseline: medium: 53.6 (20.2) (95% CI 13–89) vs. low: 59.5 (16.1) (95% CI 16–90)
				Not significant (no *p*-value given)	Medium 34.7 (26.6) (95% CI 2–90) vs. low: 39.7 (27.7) (95% CI 5–96)
				Not significant (no *p*-value given)	6 Months: medium: 24.1 (22.9) (95% CI 0–82) vs. low: 34.9 (31.7) (95% CI 0–95)
			Pain during activity (range 0–11)	Not significant (no *p*-value given)	Baseline: Treatment: 8.56 (1.58) vs. comparison: 8.54 (1.91) (95% CI −0.99 to 1.03)
				Significant (no *p*-value given)	12 Weeks: treatment: 3.79 (2.67) vs. comparison: 6.65 (3.10) (95% CI −4.65 to −1.16)
				Significant (no *p*-value given)	1 Year: Treatment: 2.76 (1.92) vs. comparison: 6.04 (2.87) (95% CI −4.68 to −1.88)
			Constant score (range 0–100)	Not significant (no *p*-value given)	Baseline: treatment: 49.96 (10.87.3) vs. comparison: 47.17 (11.53) (95% CI −3.64 to 9.23)
				Significant (no *p*-value given)	12 Weeks: treatment: 104.59 (23.12) vs. comparison: 73.08 (29.44) (95% CI 16.99–47.03)
				Significant (no *p*-value given)	1 Year: treatment: 116.24 (16.23) vs. comparison: 83.51 (26.40) (95% CI 20.19–45.27)
			Subjective improvement (%)	Significant (no *p*-value given)	12 Weeks: treatment: 57.46 (32.18) vs. comparison: 31.74 (35.60) (95% CI −5.80 to 45.64)
				Significant	1 Year: treatment: 81.36 (19.08) vs. comparison: 47.04 (36.50) (95% CI 17.68–50.96)

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Appendix (*continued*)

Author	Treatment	Placebo	Control/comparison	Outcome measures and FU time	Results – statistical	Results – words
Medium-ESWT plus kinesitherapy vs. kinesitherapy vs. postural hygiene						
Melegati et al. (2000) Non-calcific subacromial impingement syndrome	Group A: Kinesitherapy sessions (exercises: Codman, capsular stretching, isometric for rotators and deltoid, elastic resistance for the rotators, deltoid and trapezius, 6× at 3 weeks interval) ($n = 30$)		Group B: medium-ESWT (3 × 2000 pulses at 1-week interval 0.22 mJ/mm^2). Subsequently followed by kinesitherapy (Codman) ($n = 30$) 6× at 3 weeks interval Group C: controls (one session postural hygiene and joint economy suggestions) ($n = 30$)	Improvement (Constant score) % improvement in Constant score (80 days)	$p < 0.0001$ $p < 0.0001$ $p > 0.05$ $p < 0.05$ $p < 0.05$ $p < 0.05$	Within group A Within group B Within group C Group B[b] vs. group A: 27.95% Group B[b] vs. group C: 80.41% Group A[b] vs. group C: 72.81%

Low-ESWT, ≤0.11 mJ/mm^2; medium ESWT, 0.11–0.28 mJ/mm^2; high-ESWT, >0.28 mJ/mm^2.
EFD, energy flux density; ESWT, extracorporeal shock-wave therapy; RSWT, radial shock-wave therapy; FU, follow-up; Ifo, in favour of; MMT, manual muscle test; ROM, range of motion; RSWT, radial shock-wave therapy; SPADI, shoulder pain and disability index; TENS, transcutaneous electrical nerve stimulation; UCLA Shoulder Rating Scale, University of California-Los Angeles shoulder rating scale; US, ultrasound; VAS, visual analogue scale (range 0–10).
[a] Six weekly intervals until symptoms revolved, with a maximum of five treatments.
[b] In favour of.
[c] Within-group comparison.

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